Regional intercomparison of over-land precipitation retrievals

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Overview

The new University of Wisconsin-Madison algorithm uses a dimensional reduction procedure by way of principal component analysis (PCA) on the nine channels of the TRMM Microwave Imager (TMI) in order to optimally separate surface "noise" from the precipitation signatures and to more densely populate the database used for Bayesian precipitation rate estimates. In addition to producing rain rate estimates, the algorithm is unique in also yielding a complete posterior PDF of rain rates.

Petty and Li (2013b) undertook a global validation and intercomparison between the UW algorithm, the official 2A12 v.7 (TMI) retrievals, and the 2A25 (PR) rain rates, which served as "truth." The study included an evaluation of annual total precipitation on a one-degree grid and the ability to retrieve instantaneous pixel-level rain rates. Seven separate surface classes were analyzed, and for total annual precipitation, each surface class displayed significantly reduced bias and RMS error in the UW product. The instantaneous skill at observing light rain rates over troublesome surface types also showed strong improvements.

The present study extends that of Petty and Li (2013b) by examining selected overpasses over different regions of the globe.

Introduction

While considerable progress has been made with passive microwave remote sensing of precipitation, observing very light rain rates, especially over various surface types and coastlines, is still problematic for many algorithms.

The database required for Bayesian-style precipitation retrievals must be large and climatologically representative. When matches are sought in the original nine-channel observation space, the local density of the training data set can be so sparse as to yield relatively few matches. As discussed by Petty (2013), reducing the dimensionality results in a more adequately populated database, and most of the background variation due to geophysical noise can be filtered out. We can test this methodology on a variety of surface types to evaluate each algorithm's performance.

Methods

Over 300 specific TRMM overpasses, approximately ten each in 30 different meteorological and land surface categories had been identified independently by Dr. Chuntao Liu (University of Utah). The case studies selected were separated into different rain type categories: deep mesoscale convective system (MCS), shallow MCS, isolated deep convective systems (ICS), and others such as snow over land, warm rain over land, mountains, and desert. Each convective system category was further delineated into nine different tropical locations.

Both the UW algorithm results and the standard 2A12 v. 7 product were compared against the 2A25 product. Two of the more interesting products are shown visually in figures 1 and 2, and statistics for all rain events in a few chosen categories are shown in figures 3-8.

Conclusions

In most cases examined, the UW algorithm was found to outperform 2A12 by multiple metrics, especially over the desert and along coastlines. The Heidke Skill Scores show that UW is able to detect very light rain rates much better in all situations considered. All categories observed display stronger correlations for UW, and all but one category (MCS Shallow Australia) resulted in markedly reduced RMS values.

These results validate the algorithm strategy developed by Petty (2013) and Petty and Li (2013a) to optimally isolate precipitation signatures from variable land surface backgrounds, a strategy that is now also being implemented for the GPM Microwave Imager (GMI).

Ongoing work

The same retrieval methodology is now being used to develop an Bayesian algorithm for the GPM Microwave Imager (GMI), trained on surface rain rates provided by the Ku-band radar carried on the same satellite. Also, the dimensional reduction and signal optimization technique will be adapted to the GPROF retrievals algorithm of Kummerow et al. (2011)
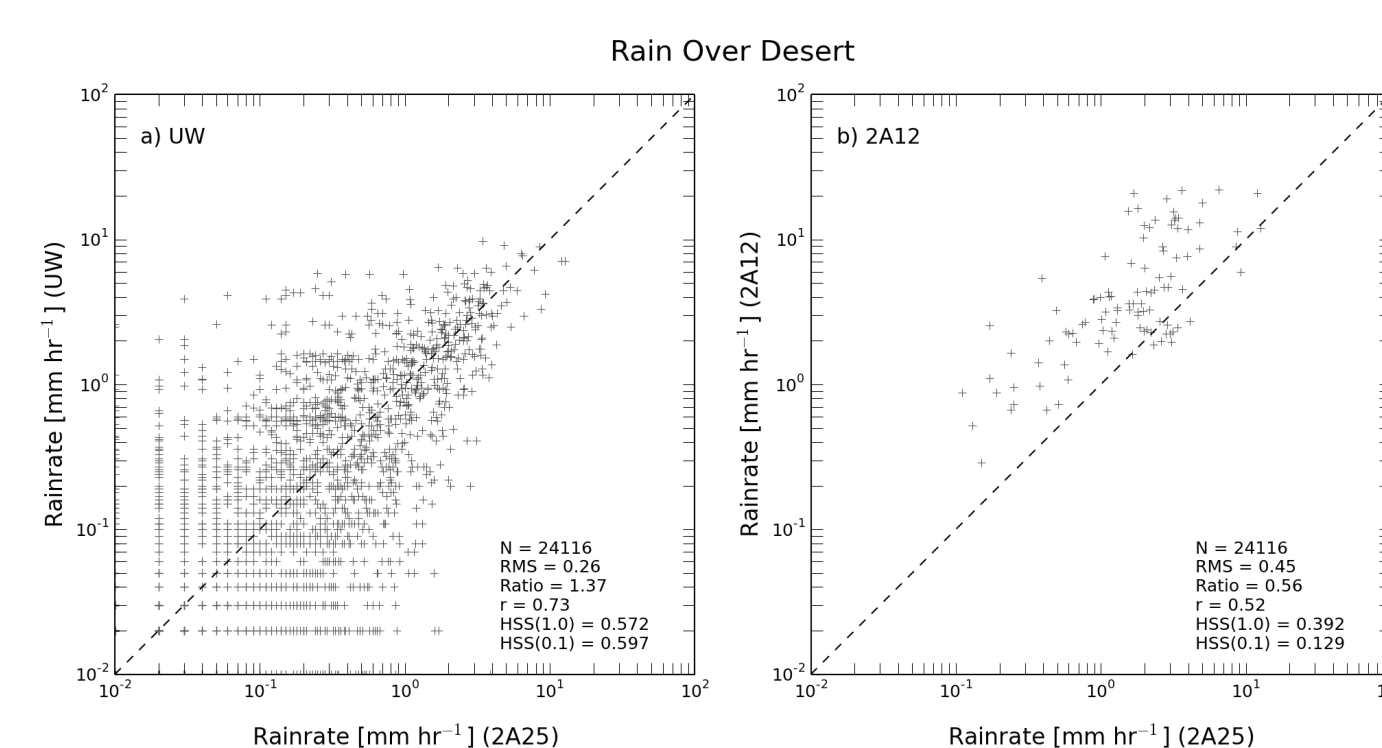

Figure 1: Swaths from TRMM orbit 7041 compared to 85V, 37H and pseudochannels

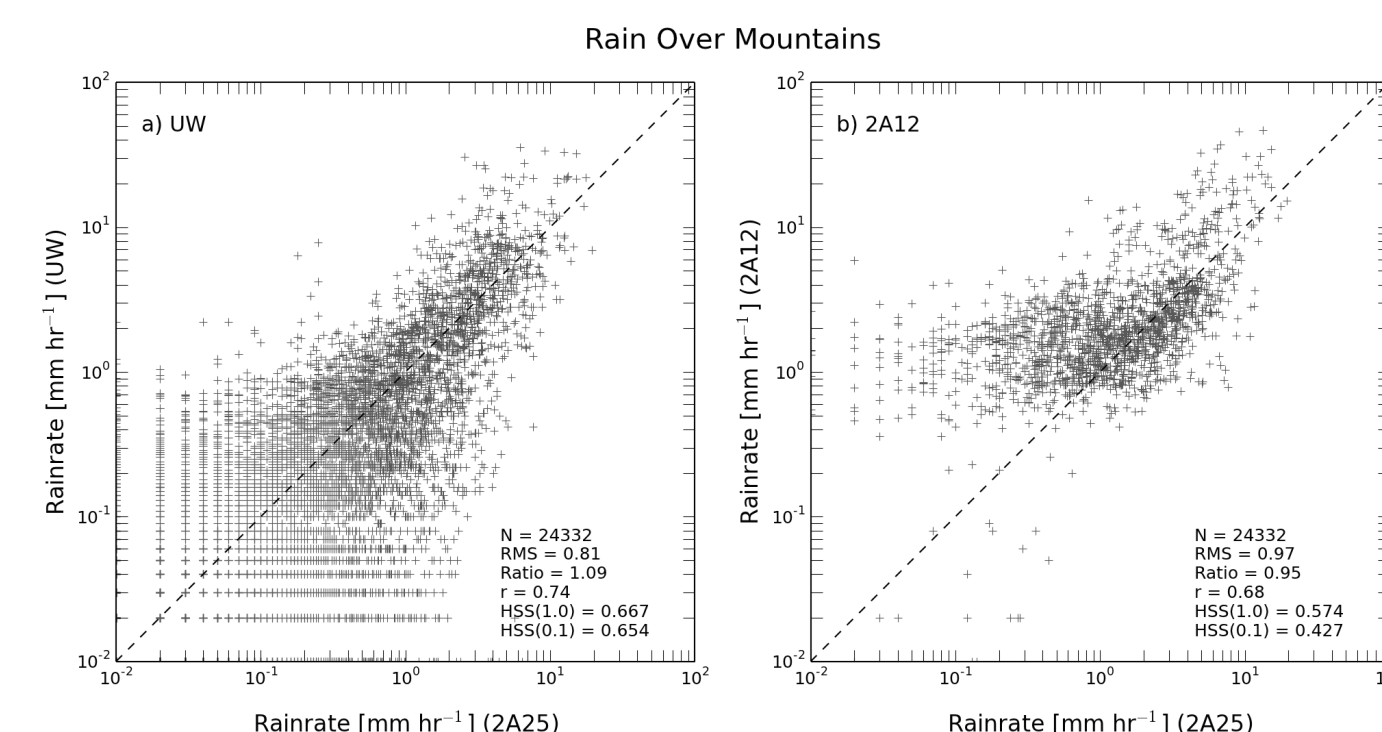Figure 2: Swaths from TRMM orbit 34722 compared to 85V, 37H and pseudochannels

Results

Figure 3: Scatter plot containing statistics for all desert cases.

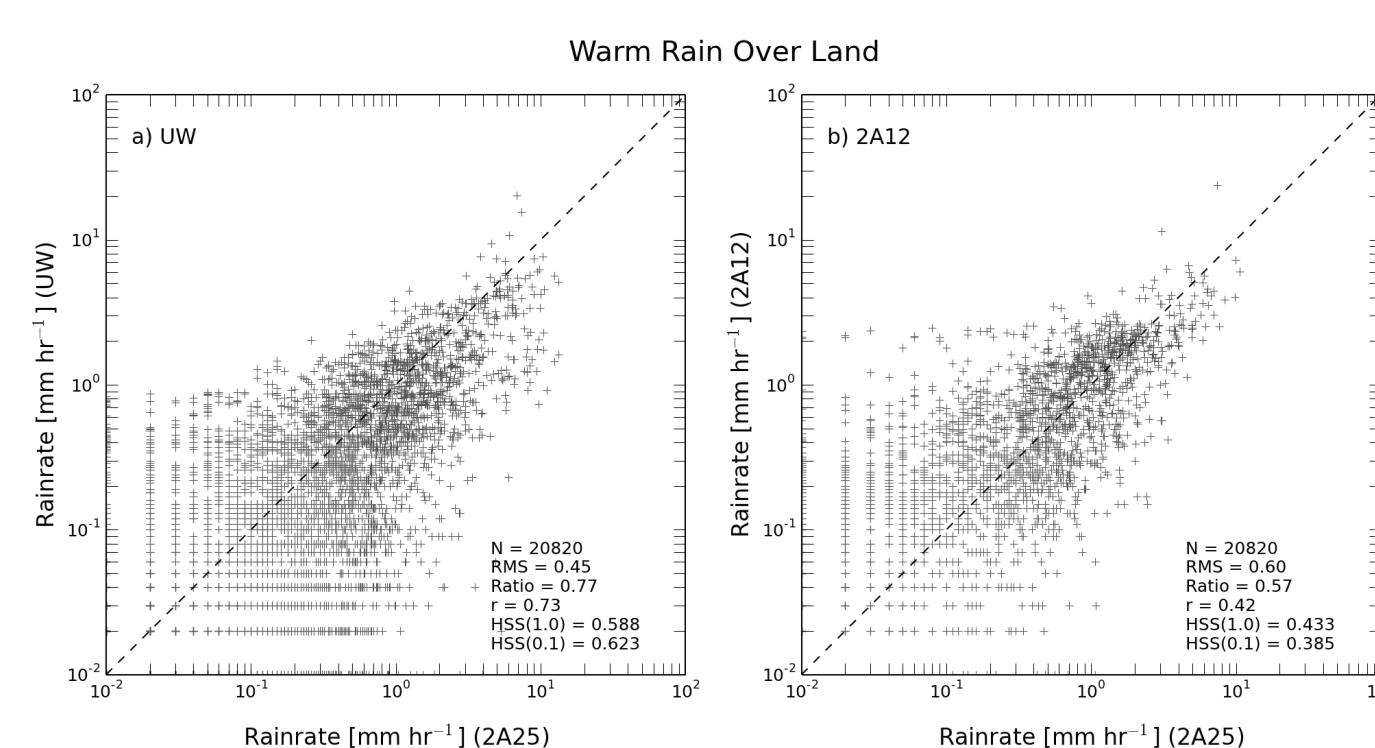
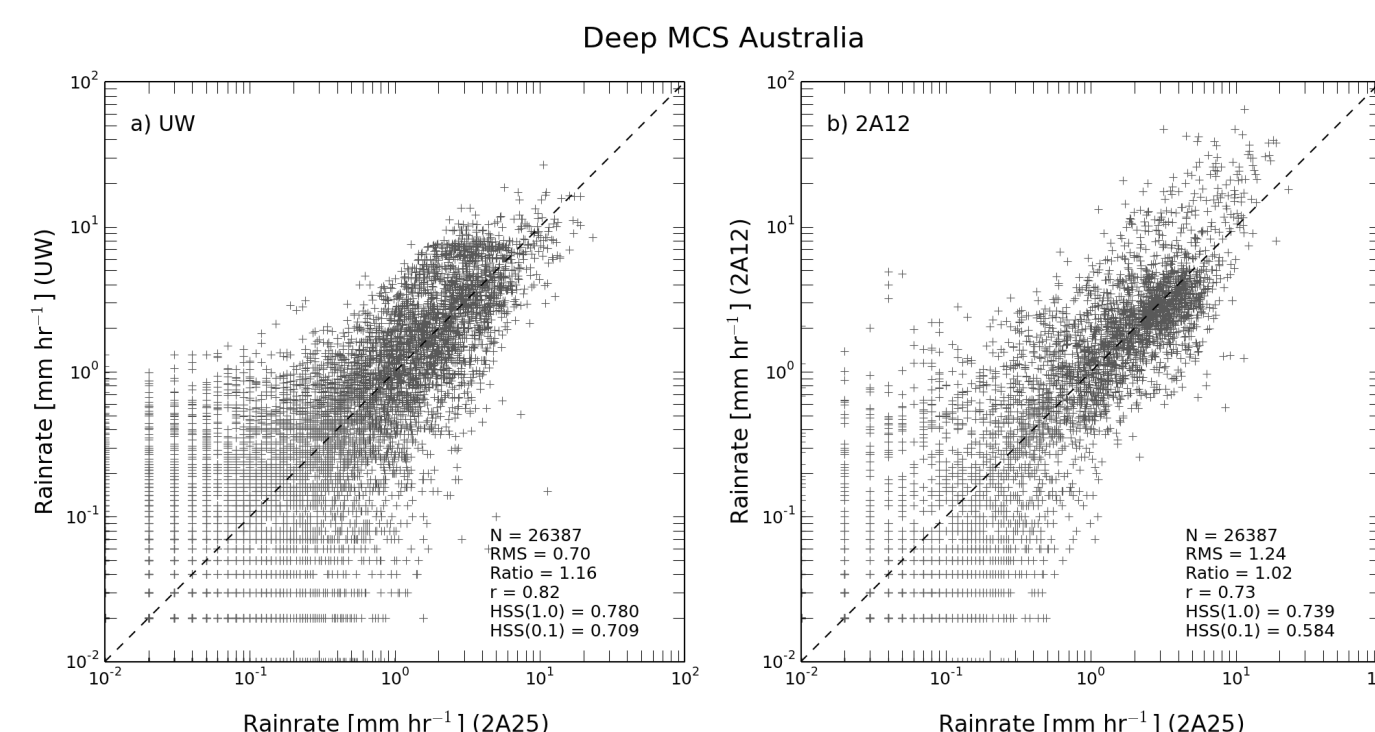Figure 4: Scatter plot containing statistics for all warm rain over land cases.

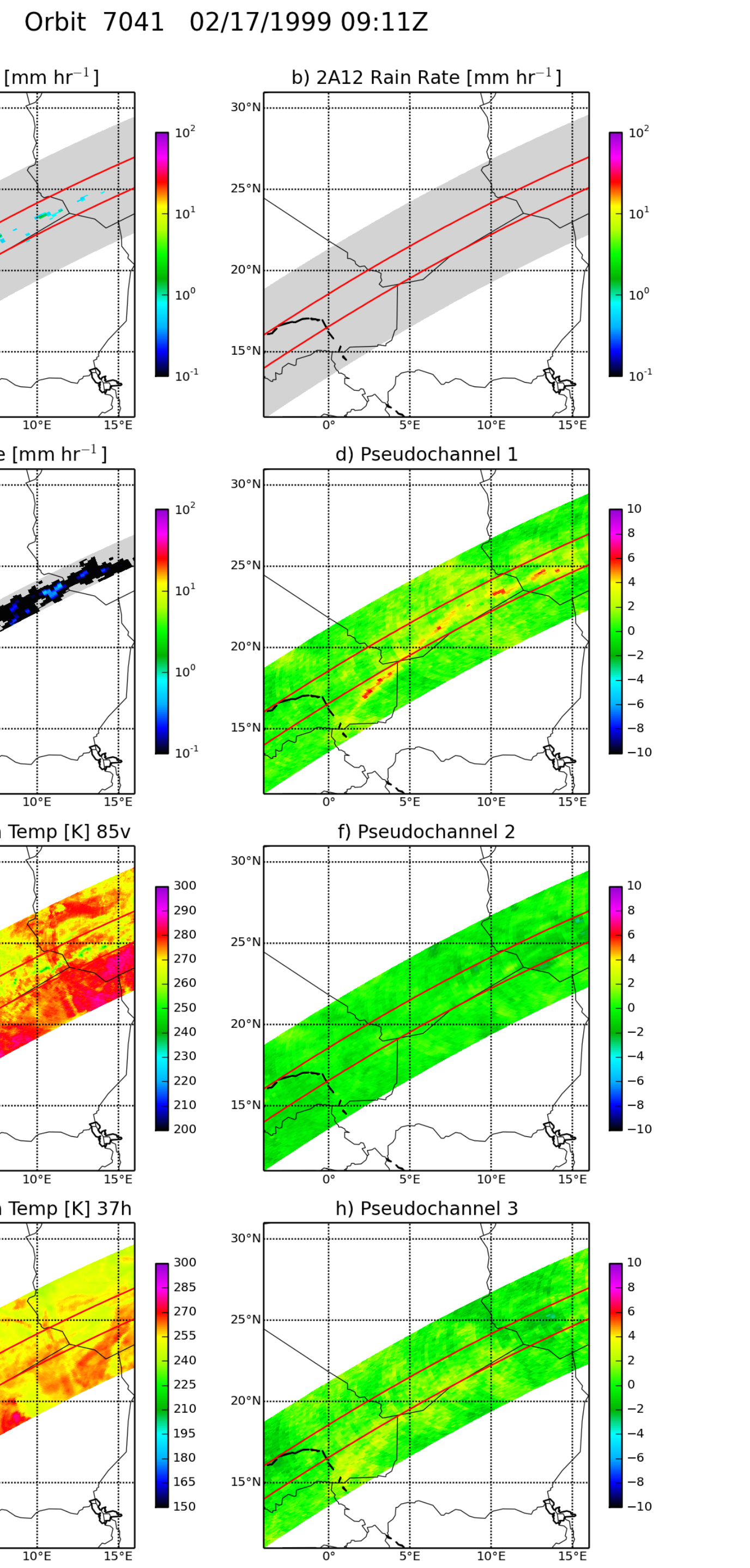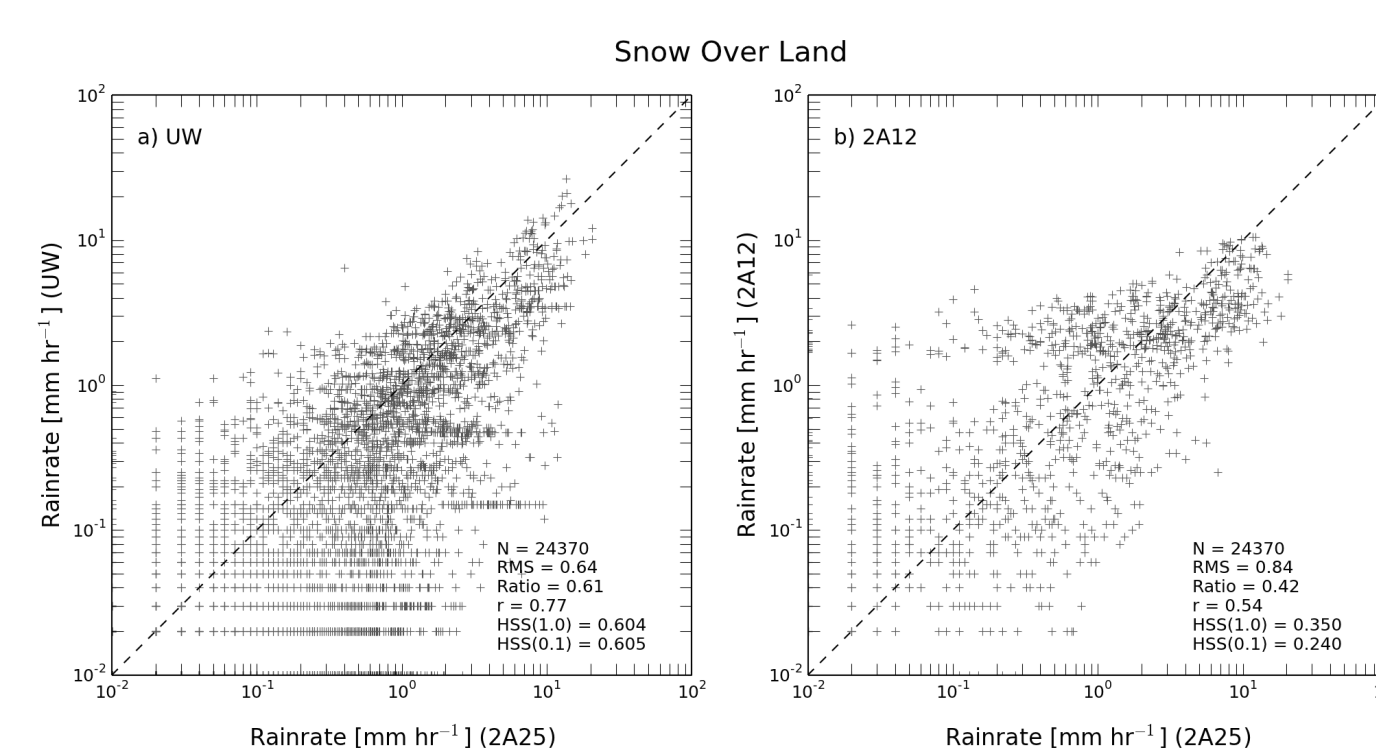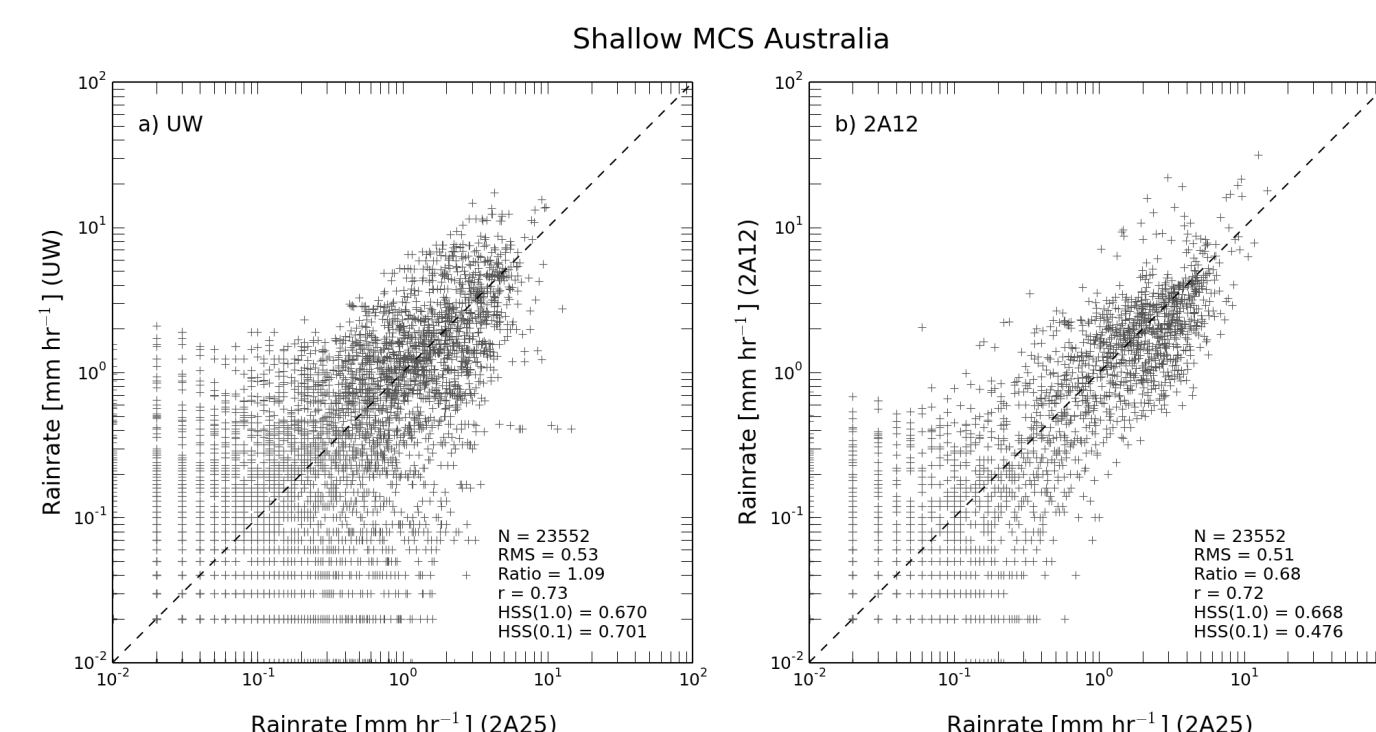Figure 5: Scatter plot containing statistics for all snow over land cases.

Figure 6: Scatter plot containing statistics for all mountain cases.

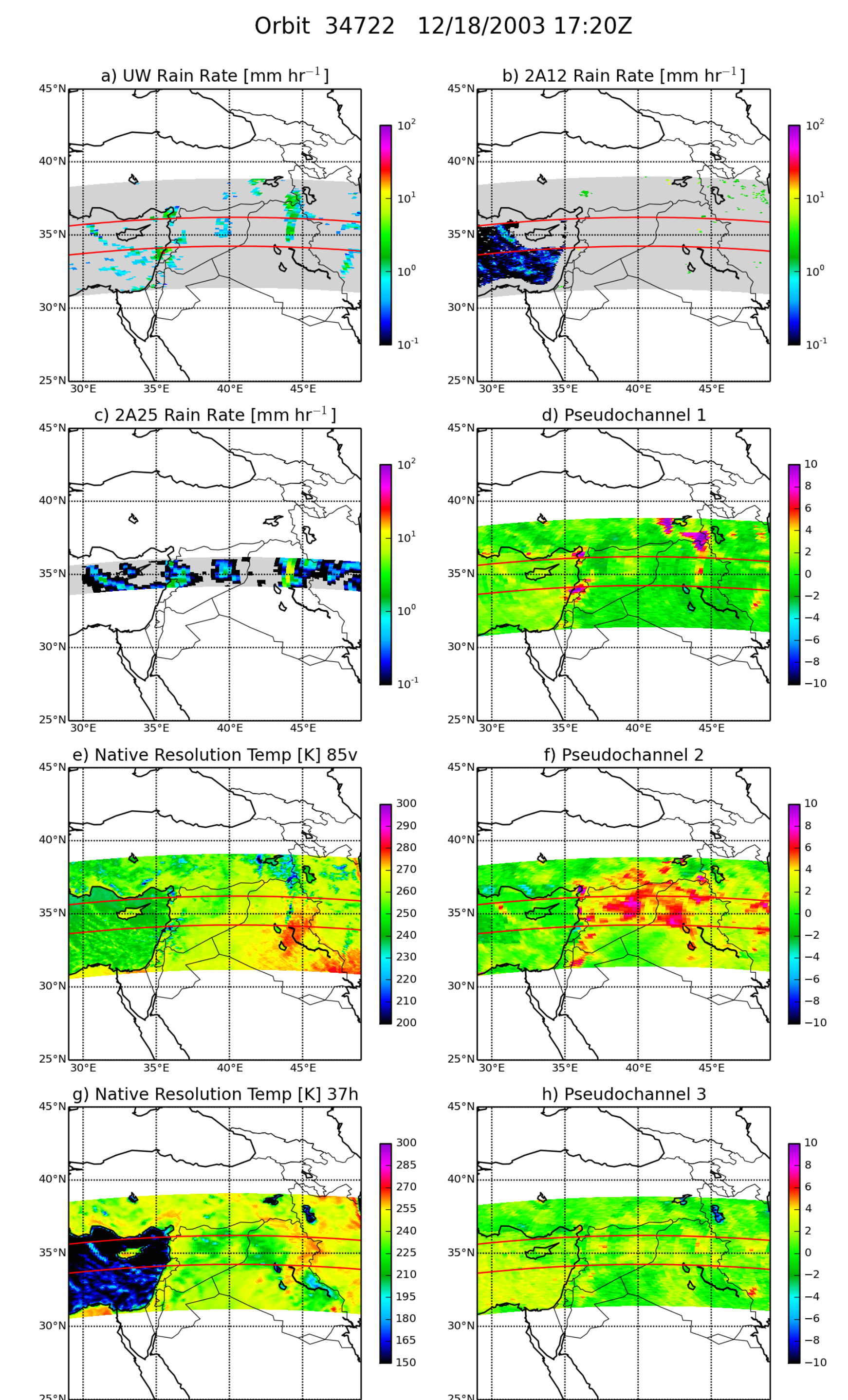Figure 7: Scatter plot containing statistics for all deep MCS Australia cases.

Figure 8: Scatter plot containing statistics for all shallow MCS Australia cases.

References

[1] Kummerow, C. D., S. Ringerud, J. Crook, D. Randel, and W. Berg, 2011: An observationally generated a priori database for microwave rainfall retrievals. *J. Atmos. Oceanic Technol.*, **28**, 113–130.

[2] Petty, G. W., 2013: Dimensionality reduction in bayesian estimation algorithms. *Atmos. Meas. Tech.*, **6**, 2267–2276.

[3] Petty, G. W. and K. Li, 2013a: Improved passive microwave retrievals of rain rate over land and ocean. Part I: Algorithm description. *J. Atmos. Oceanic Technol.*, **30**, 2493–2508.

[4] Petty, G. W. and K. Li, 2013b: Improved passive microwave retrievals of rain rate over land and ocean. part II: Validation and intercomparison. *J. Atmos. Oceanic Technol.*, **30**, 2509–2526.

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